Title: Swarm-based UAV Simulation Incorporating ACO and Optical-based Constraints

Authors: Tarek A. El Doker and Timothy W. Olson, Machine Perception Laboratory, Northern Arizona University
Tarek.ElDoker@nau.edu

Abstract:

A multi-layered simulation tool has been developed to aid in the analysis of agent-based unmanned aerial vehicle (UAV) swarms, aimed at efficiently seeking and destroying various hostile military targets in desert terrains.

Layers of the swarm simulation tool include:

- User layer: the user can specify various parameters through a C-based graphical interface. Parameters include: UAV count, target count, inter-agent communication bandwidth, inter-agent communication distance, swarm/single agent toggle, target specs, and environmental specs including topographical information.
- Network layer: ant colony optimization (ACO) algorithms are used to route and synchronize UAV communication. User-specified line-of-sight communication incorporates topographical information for a more realistic demo aimed at best emulating real-world scenarios. The UAV swarm maintains maximum network connectivity by ubiquitously reconfiguring topology, adapting to changes in target detection, topography, terrain, bandwidth limitations, line-of-sight etc
- Optical layer: wavelet-based optical recognition and Hough-domain clustering is used for fast detection of spatial signatures left by military targets in desert terrains. Such targets can be either mobile or stationary.
- Action layer: discrete states are used to specify tasks involving swarm. States include: search, track, flock, attack, and others. Swarm-based cooperation and team work is achieved with various ant-based algorithms. UAVs change states stigmergetically based upon pheromone updates, in a novel ACO-inspired methodology.

New benchmarks involving a more sophisticated optical subsystem are suggested in order for swarm models to better contribute to such simulation problems. Also, comparisons to prominent swarm and agent-based modeling tools are attempted. Studies show increased efficiency and accuracy in both detection and classification of various targets, pertinent to the state of the art.

The derived results shape recommendations for a new approach to various UAV species development. These UAV species are biologically-inspired, and would drastically reduce the development cost while improving efficiency and increasing effectiveness.